MERCURY AND AIR TOXIC ELEMENT IMPACTS OF COAL COMBUSTION BY-PRODUCT DISPOSAL AND UTILIZATION

Quarterly Technical Report

for the period July 1, 2004, through September 30, 2004

Prepared for:

AAD Document Control

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October 2004

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ABSTRACT

A large quantity of laboratory data was generated this quarter. Analyses for pH, moisture content, and loss on ignition, as well as arsenic, cadmium, chromium, lead, mercury, and selenium total elemental concentrations are presented in this report. In addition, results from toxicity characteristics leaching procedure (TCLP), synthetic groundwater leaching procedure (SGLP), and 30- and 60-day long-term leaching (LTL) leachates are summarized. A long-term ambient-temperature mercury vapor transport experiment was completed yielding 187 days of data. Mercury and selenium thermal desorption curves are also provided.

The Energy & Environmental Research Center (EERC) and University of Nevada conducted field investigations at a lignite fired-power plant disposal site. The site will allow the EERC and EPRI to share analysis and produce a complete data set and some replicate analyses. Sample analysis will be initiated next quarter.

Researchers gave project-related presentations at the Department of Energy (DOE) National Energy Technology Laboratory (NETL) Mercury Project Review Meeting, Stack Emissions Symposium, and MEGA Symposium. Three abstracts were submitted for consideration at PITTCON®2005 and two abstracts were accepted to the 2005 World of Coal Ash. A presentation was prepared for the Western Fuels Symposium.

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EXECUTIVE SUMMARY

A large quantity of laboratory data was generated this quarter. Analyses for pH, moisture content, and loss on ignition, as well as arsenic, cadmium, chromium, lead, mercury, and selenium total elemental concentrations are presented in this report. In addition, results from TCLP, SGLP, and 30- and 60-day LTL leachates are summarized. A long-term ambient-temperature mercury vapor transport experiment was completed yielding 187 days of data. Mercury and selenium thermal desorption curves are also provided.

Results from laboratory experiments conducted this quarter continue to support the preliminary conclusions drawn in the study:

- No correlation has been observed between total mercury and leachable mercury.
- Most samples act as mercury sinks in ambient temperature vapor-phase release experiments.
- Mercury is generally released at temperatures greater than 200°C.

Leachate ranges for the elements were <2.0–1500 ppb arsenic, <0.20–37 ppb cadmium, <2.0–680 ppb chromium, <2.0–37 ppb lead, <0.010–1.04 ppb mercury, <2.0–280 ppb nickel, and <2.0–8600 ppb selenium. Four of the 12 CCBs analyzed for vapor release showed an average release of mercury during the final 90-day collection period and five CCBs showed mercury release over the duration of the entire 187 days of the experiment. Preliminary selenium thermal desorption curves showed a very gradual but slow release that increased gradually with respect to time and temperature.

The EERC and University of Nevada conducted field investigations at a lignite fired-power plant disposal site. The site will allow the EERC and EPRI to share analysis and produce a complete data set and some replicate analyses. Sample analysis will be initiated next quarter.

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MERCURY AND AIR TOXIC ELEMENT IMPACTS OF COAL COMBUSTION BY-PRODUCT DISPOSAL AND UTILIZATION

INTRODUCTION

This effort is focused on the evaluation of coal combustion by-products (CCBs) for their potential to release mercury and other air toxic elements under different controlled laboratory conditions and will investigate the release of these same air toxic elements in select disposal and utilization field settings to understand the impact of various emission control technologies. Information will be collected, evaluated, and interpreted together with past Energy & Environmental Research Center (EERC) data and similar data from other studies. Results will be used to determine if mercury release from CCBs, both as currently produced and as produced with mercury and other emission controls in place will potentially impact CCB management practices. The project will provide data on the environmental acceptability of CCBs expected to be produced in systems with emission controls for typical disposal and utilization scenarios. The project will develop baseline information on release mechanisms of select elements in both conventional and modified or experimental CCBs. The modified or experimental CCBs will represent those from systems that have improved emission controls. Controlling these emissions has a high potential to change the chemical characteristics and environmental performance of CCBs. Development of reliable methods to determine the release of mercury from CCBs will provide a means of evaluating the environmental risk associated with CCB management practices. Using appropriate methods to develop data about currently produced CCBs and those produced under experimental or simulated conditions will provide a baseline for the CCB industry to understand the impact of various emission control technologies.

EXPERIMENTAL

Literature Search

Researchers continued to collect publications related to mercury, air toxic elements, and CCBs. Citations and abstracts were assembled and added to the Mercury and Air Toxic Element document database located at www.undeerc.org/carrc/mercury. This database is password-protected and only available to project researchers and sponsors.

Analytical Methods Selection

Sample selection continued for the U.S. Department of Energy (DOE) National Energy Technology Laboratory (NETL) informal interlaboratory round-robin experiment on leaching procedures.

Sample Identification and Selection

Sample priorities were reviewed according to information gleaned from discussions with sample submitters and information from sample identification forms.

Chemical and Physical Characterization

Samples were analyzed for total mercury and air toxic element concentrations.

The pH values of numerous CCBs using 1 M KCl were determined. This was done by making a slurry of 25 mL of 1 M KCl solution with 10 grams of CCB and measuring the pH. Moisture content and loss on ignition (LOI) were determined on several samples.

Laboratory Evaluation of Air Toxic Element Release

Leaching

Thirty- and 60-day long-term leaching (LTL) was completed on several samples. Results were received for toxicity characteristics leaching procedure (TCLP), synthetic groundwater leaching procedure (SGLP), and 30- and 60-day LTL leachings performed last quarter. LTL was initiated on four samples.

Vapor Transport

The long-term ambient-temperature mercury vapor release experiment on the first sample set was completed with the final 90-day collection measurements. The total mercury content of five samples was analyzed upon completion of the experiment.

The blanking process began for the second batch of long-term ambient-temperature mercury vapor release experiments.

Mercury thermal desorption curves were generated for numerous samples (Table 1) including primarily samples of fly ash with and without activated carbon. Initial attempts were made to generate arsenic and selenium thermal curves on a limited number of samples. However, the apparatus needs to be improved in order to generate arsenic and selenium thermal curves. Future experiments will address this issue.

Microbiological Release

The overall buffer system was changed to eliminate interferences introduced into the solid-phase microextraction (SPME) analysis by the old buffer system. Initial experiments indicate that the new buffer system may greatly reduce these interferences. The new buffer system consists of L-glutamic acid, potassium phosphate monobasic, and D-(+)-glucose. The new buffer system was investigated on five samples to determine the amount of sulfuric acid necessary for neutralization of the CCB pH.

Three of the five samples were chosen to evaluate the microbiologically mediated release of mercury and were added to containers at the end of the quarter. The samples will be evaluated under aerobic and anaerobic glucose-fed bacteria conditions.

Table 1. CCB Samples Tested for Mercury Thermal Desorption

ID No.	Sample Type	ID No.	Sample Type
02-002	Fly ash + activated carbon	02-073	Fly ash
02-003	Fly ash + activated carbon	02-074	Fly ash
02-004	Fly ash + activated carbon	02-076	Fly ash + activated carbon
02-005	Fly ash + activated carbon	03-065	FGD Gypsum
02-006	Fly ash + activated carbon	03-075	Fly ash
02-007	Fly ash + activated carbon	03-076	Fly ash + activated carbon
02-069	Fly ash + activated carbon	03-077	Fly ash
02-070	Fly ash	03-078	Fly ash
02-071	Fly ash + activated carbon	03-079	Fly ash
02-072	Fly ash	03-080	Fly ash

Field Investigation

A proposed statement of work was received from Mae Gustin at the University of Nevada for field work planned for September 2004. Discussions to identify an appropriate field site continued. Discussions were also held with Ken Ladwig, EPRI, about potentially sharing the field site for EERC and EPRI–DOE NETL-funded efforts in order to develop complete data and replicate analyses from the field.

A field investigation was completed at a lignite-fired power plant on September 17–24, 2004. Field work was completed by Mei Xin and Mark Engle, University of Nevada – Reno (UNR), and Erick Zacher, EERC, using different methods at various disposal sites. University of Nevada personnel used a mercury flux chamber to evaluate mercury vapor. Mr. Zacher collected mercury vapor samples by pumping air through gold-coated quartz traps to be analyzed for inorganic mercury and tubes containing Supelco Carbotrap to be analyzed for organomercury species.

Liquid and replicate (EERC and UNR) solid samples were obtained for laboratory testing. Solid composite samples were taken of the substrate on which the mercury air sampling was conducted. Composite samples included a fly ash sample from a disposal site, a FGD scrubber material mixed with pyrites from a disposal site, a soil sample from a reclaimed fly ash landfill, bottom ash and FGD samples from a wet disposal pond, and FGD stabilized with fly ash from a wet disposal pond. Liquid samples were collected at wet disposal ponds where possible.

Laboratory analysis was initiated at the EERC. Gold-coated quartz traps were analyzed utilizing double-gold amalgamation with atomic fluorescence detection. The liquid samples were evaluated using SPME with gas chromatographic (GC) separation and atomic fluorescence (AF) detection of organomercury compounds.

Data Reduction and Interpretation

A preliminary comparison of the total mercury content to the dominant carbon form identified in 55 samples was made.

Correlations between total and leachable mercury concentration data were accessed.

Technology Transfer

Several presentations were made regarding the activities of this project. Debra Pflughoeft-Hassett gave a presentation entitled “Mercury Impacts on By-Products” at the DOE NETL Mercury Project Review July 14–15, 2004, in Pittsburgh, Pennsylvania. Ms. Pflughoeft-Hassett also presented “The Current State of the Science Related to the Rerelease of Mercury from Coal Combustion Products” at the 2nd Annual Scientech Stack Emissions Symposium, July 28–30, 2004, in Clearwater Beach, Florida.

David Hassett and Erick Zacher attended the EPRI/EPA/DOE/Air &Waste Management Association Power Plant Air Pollutant Control MEGA Symposium held August 30–September 2, 2004, in Washington, D.C. Mr. Hassett presented a paper entitled “Determination of Organomercury Compounds from Microbiologically Mediated Mercury Release Experiments Using Gas Chromatography with SPME Sample Introduction after Boroethylation, Boropropylation, or Borophenylation” and Mr. Zacher presented a poster entitled “Long-Term Storage of Mercury Sampled from Ambient Air.”

Three abstracts, “A Method for Determining Microbiologically Mediated Release of Elemental and Organomercury Compounds from CCBs Using SPME, Gas Chromatography, and Atomic Fluorescence,” “Long-Term Storage of Air-Sampled Mercury on Gold-Coated Quartz Tubes,” and “Real-Time Thermal Devolatilization of Mercury and Mercury Compounds from CCBs Detected with Atomic Absorption Spectrometry,” were submitted for consideration at PITTCON® 2005, February 27–March 4, 2005, in Orlando, Florida.

Five abstracts were submitted for consideration and accepted to the 2005 World of Coal Ash Symposium, April 11–15, 2005, Lexington, Kentucky. The following two abstracts submitted pertain to ongoing mercury research: “Organomercury Compound Determination from Microbiologically Mediated CUB Samples,” and “Quantitation and Interpretation of Release of Mercury from Coal Utilization By-Products.”

Ms. Pflughoeft-Hassett prepared a presentation entitled “Mercury, Coal Combustion By-Products, and the Potential for Rerelease” for the EERC Western Fuels Symposium, October 12–14, 2004, in Billings, Montana.

RESULTS AND DISCUSSION

Literature Search

This quarter, 42 documents were added to the Mercury and Air Toxic Element database, which now contains 406 documents.

Analytical Methods Selection

Samples were received from several utilities burning subbituminous or lignite coal to provide an additional fly ash sample for evaluation in the DOE NETL interlaboratory round-robin experiment. From these samples, one was chosen to provide to other participants in the round-robin experiment. This evaluation intends to provide the industry with appropriate leaching procedures for CCBs.

Sample Identification and Selection

Seventy-three samples were obtained for evaluation in this project; 47 are samples of FGD material or fly ash from systems where no mercury control is present; 26 are from systems with mercury control in place, of which 22 are fly ash combined with injected activated carbon. Table 2 summarizes the numbers of samples that have been evaluated in release experiments and characterized for related parameters.

Chemical and Physical Characterization

Samples were analyzed for total arsenic, cadmium, chromium, lead, mercury, and selenium concentrations; 31 were analyzed for total mercury and 43 samples plus 5 replicates were analyzed for total air toxic element concentrations. The results are shown in Table 3.

Table 4 shows the pH values for 47 samples—most of them alkaline—obtained using 1 M KCl. The values in Table 3 are similar to those obtained using distilled water; therefore, the use of 1 M KCl for determination of pH values has been terminated. It is likely that the high concentration of total dissolved solids generated in the pH determination eliminated the double electric-layer effect that requires the use of KCl solution in the determination of pH in other types of solids.

Table 5 shows the moisture content and LOI for samples analyzed this quarter. Also included are samples from last quarter, which had the LOI reported incorrectly.

Laboratory Evaluation of Air Toxic Element Release

Leaching

Results were received for TCLP, SGLP, and 30- and 60-day LTL leachates. The results of all leaching tests are shown in Table 6. The latest set of leachate data appears to indicate nickel contamination, which will be investigated.

The results presented include one TCLP, 10 SGLP, 21 30-day LTL, and 24 60-day LTL samples, plus one 60-day LTL replicate analyzed for arsenic, cadmium, chromium, lead, nickel, and selenium. Two blanks—a distilled water blank and a container blank—also were analyzed. Mercury leachate values are shown for one TCLP, 9 SGLP, 11 30-day LTL, and 10 60-LTL samples, plus two SGLP and four 60-day LTL replicates. Mercury leachate results for 24 samples, one replicate, and two blanks are expected next quarter. The results shown in Table 6 included replicate analyses of five samples previously reported.

Table 2. Summary of Year 1 and Year 2 Accomplishments

Task	Proposed through Year 2 (without/with Hg Control)	Actual Accomplished to Date (without/with Hg Control)*
Leaching	25/40	35/24
Vapor Transport 1 (elevated temperature)	25/40	20/18
Vapor Transport 2 (ambient temperature)	9/12	3/4
Microbiological	6/6	1/1
Sample Analysis		
Total Hg	NA	47/26
Total As, Cd, Cr, Pb, Ni, and Se	NA	31/11
Carbon Forms	NA	17/9
LOI	NA	15/21

* Total number of samples without mercury control were 47 and with mercury control were 26.
NA – not applicable.

A wide range of leachate concentrations were reported. The ranges for the elements were <2.0–1500 ppb arsenic, <0.20–37 ppb cadmium, <2.0–680 ppb chromium, <2.0–37 ppb lead, <0.010–1.04 ppb mercury, <2.0–280 ppb nickel, and <2.0–8600 ppb selenium.

Vapor Transport

The gold-coated quartz traps were analyzed for a second 90-day period of mercury capture in the long-term ambient-temperature mercury release task. Results from the entire experiment of the first sample set are shown in Figure 1. Four of the 12 CCBs showed an average release of mercury during the final 90-day collection period and five CCBs showed mercury release over the duration of the entire 187 days of the experiment. The release of mercury, expressed as pg/g/day, was less for most samples in the final 90-day collection period than for the previous 90-day collection period.

The CCB sample from five of the 24 containers was evaluated for total mercury content after completion of the long-term ambient-temperature mercury vapor release experiment for the first sample set. The mercury value is compared to the initial mercury value in Table 7. The final total mercury content was higher for all samples tested. It was, however, within the statistically acceptable margin of error for all but Sample 03-018.

Mercury thermal desorption curves were generated for 20 CCBs. Most samples generated either one or two peaks in thermal desorption. At this time, it is not possible to identify the mercury species responsible for each of the peaks. Work is ongoing to solve this problem.

Preliminary arsenic and selenium thermal desorption curves showed a gradual, slow release that increased gradually with respect to time and temperature. Initial arsenic and selenium thermal curves generated did not lead to unequivocal conclusions.

Table 3. Mercury and Trace Element Total Concentrations, μg/g

ID No.	Sample Type	As	Cd	Cr	Pb	Hg	Ni	Se
02-006	Fly ash	37.4	2.0	111	60.2	5.81	50.6	36.6
03-004	Fly ash	72.2	<1.0	142	65.4	<0.10	68.3	<1.0
03-005	Fly ash	71.4	<1.0	148	72.6	<0.10	85.7	<1.0
03-006	Fly ash	78.0	1.4	135	94.3	0.19	60.4	5.3
03-007	Fly ash	68.6	1.1	138	89.0	0.14	55.2	1.1
03-007	Fly ash	72.1	<1.0	135	72.4	NA	87.4	<1.0
03-016	Fly ash	33.7	<1.0	59.6	25.6	<0.10	59.5	<1.0
03-017	Fly ash	40.1	<1.0	57.7	30.4	0.22	56.5	<1.0
03-018	Fly ash	54.7	<1.0	61.5	40.4	0.29	54.0	1.3
03-019	Fly ash	73.9	<1.0	64.8	47.4	2.22	51.4	10.5
03-060	Fly ash	19.4	1.9	76.7	82.2	1.86	67.6	<1.0
03-061	Fly ash	37.8	1.8	44.2	58.1	0.58	79.0	26.8
03-061	Fly ash	43.4	1.9	82.4	58.4	NA	95.8	<1.0
03-062	Fly ash	43.3	<1.0	54.4	30.3	0.49	57.6	<1.0
03-063	Fly ash	45.5	<1.0	128	37.1	<0.10	23.3	<1.0
03-065	Gypsum	<1.0	<1.0	2.9	<1.0	<0.10	<1.0	<1.0
03-067	FGD slurry	<1.0	<1.0	6.6	<1.0	<0.10	2.8	<1.0
03-074	Dust collector ash	17.1	<1.0	23.3	5.0	<0.01	16.2	<1.0
03-075	Fly ash	42.2	1.6	26.1	58.9	1.40	25.4	<1.0
03-076	Fly ash	25.6	<1.0	25.5	17.0	0.55	24.6	<1.0
03-077	Fly ash	36.8	2.8	17.1	137	2.03	17.8	3.7
03-079	Fly ash	351	2.1	83.2	68.3	0.78	40.9	<1.0
03-080	Fly ash	157	1.1	66.1	39.9	0.44	63.5	<1.0
03-081	Fly ash	492	3.6	85.2	124	0.46	68.4	<1.0
03-082	FGD filtercake	<1.0	<1.0	10.4	2.2	0.22	3.5	<1.0
03-083	Fly ash	163	3.5	134	258	<0.10	252	<1.0
03-083	Fly ash	169	3.7	139	272	NA	266	<1.1
03-084	Fixated scrubber sludge	53.4	1.2	53.6	80.3	0.18	87.2	<1.1
03-085	Fly ash	145	2.6	124	247	<0.10	277	<1.0
03-086	FGD filtercake	<1.1	<1.0	10.2	4.4	0.16	4.0	<1.1
03-087	Fixated scrubber sludge	53.8	1.0	51.6	86.7	0.14	98.7	<1.0
03-088	Fly ash	44.0	8.6	160	249		74.5	<1.0
03-089	FGD	<1.0	1.9	4.1	2.1	<0.13	<0.9	<1.0
04-003	Fly ash	42.2	<1.0	132	60.5	0.69	75.9	<1.0
04-003	Fly ash	49.8	<1.0	138	60.4	NA	77.2	6.3
04-004	Fly ash	31.5	<1.0	144	55.7	<0.10	81.6	<1.0
04-006	Fly ash	5.9	<1.0	43.8	38.8	0.14	26.1	<1.0
04-007	Fly ash	7.1	<1.1	64.9	29.1	0.52	22.0	<1.1
04-029	Fly ash	31.1	1.1	63.7	38.6	0.26	39.9	<1.0
04-030	Fly ash	136	3.3	92.8	85.3	0.15	24.2	<1.0
04-031	Fly ash	134	3.2	91.8	83.4	0.17	28.2	<1.1
04-032	Fly ash	161	3.4	94.8	74.9	0.47	40.0	5.4
04-033	Fly ash	148	2.9	86.5	74.9	1.43	29.1	5.7
04-034	Fly ash	NA	NA	NA	NA	0.42	NA	NA
04-035	Fly ash	36.0	<1.0	55.4	21.9	0.16	17.2	<1.0
04-036	Fly ash	46.3	<1.0	49.1	19.1	0.29	23.8	<1.0
04-036	Fly ash	43.4	<1.0	48.4	18.3	NA	23.1	<1.0
04-037	Fly ash	NA	NA	NA	NA	0.44	NA	NA
04-038	Fly ash	NA	NA	NA	NA	0.80	NA	NA
04-039	Fly ash	NA	NA	NA	NA	0.77	NA	NA
04-040	Fly ash	NA	NA	NA	NA	0.51	NA	NA
04-041	Fly ash	NA	NA	NA	NA	0.29	NA	NA
04-042	Fly ash	NA	NA	NA	NA	0.37	NA	NA
04-043	Fly ash	NA	NA	NA	NA	0.69	NA	NA
04-044	Fly ash	NA	NA	NA	NA	0.88	NA	NA
04-045	Fly ash	NA	NA	NA	NA	0.85	NA	NA
04-050	Soil	NA	NA	NA	NA	0.03	NA	NA
04-054	Fly ash	NA	NA	NA	NA	17.7	NA	NA
99-188	Fly ash + dry FGD	14.7	<1.1	26.3	37.0	NA	12.9	<1.1

Table 4. CCB pH Values using 1 M KCl

ID No.	Sample Type	pH	ID No.	Sample Type	pH
02-002	Fly ash	3.51	03-063	Fly ash	11.62
02-003	Fly ash	3.98	03-074	Dust collector ash	12.79
02-006	Fly ash	10.48	03-075	Fly ash	12.74
02-007	Fly ash	3.52	03-076	Fly ash	12.81
02-070	Fly ash	10.11	03-079	Fly ash	11.63
02-071	Fly ash	9.38	03-080	Fly ash	11.84
02-072	Fly ash	10.16	03-081	Fly ash	11.05
02-073	Fly ash	12.72	03-083	Fly ash	4.59
02-074	Fly ash	12.69	03-084	Fixated scrubber sludge	12.30
02-076	Fly ash	10.66	03-087	Fixated scrubber sludge	11.75
03-004	Fly ash	4.69	04-003	Fly ash	9.42
03-005	Fly ash	4.48	04-004	Fly ash	10.10
03-006	Fly ash	4.72	04-006	Fly ash	11.76
03-007	Fly ash	4.42	04-007	Fly ash	12.82
03-012	Fly ash	12.31	04-029	Fly ash	12.62
03-013	Fly ash	11.06	04-031	Fly ash	11.73
03-014	Fly ash	10.04	04-032	Fly ash	9.42
03-016	Fly ash	12.82	04-033	Fly ash	10.98
03-017	Fly ash	12.84	04-035	Fly ash	12.83
03-018	Fly ash	12.76	04-036	Fly ash	12.82
03-019	Fly ash	12.38	04-050	Soil	7.64
03-060	Fly ash	10.95	04-054	Fly ash	9.43
03-061	Fly ash	11.96	99-188	Fly ash + dry FGD	12.53
03-062	Fly ash	12.81			

Microbiological Release

The initial pH of the five samples evaluated ranged from near 6 to above 12. Acid was added over time to maintain a near-neutral pH. Ultimately, acid was added to the sample with an initial pH near 6 because it increased over time.

Field Investigation

Results from the mercury vapor measurements were not immediately available in the field. The gold-coated quartz traps were analyzed and results are currently under interpretation. SPME determinations of organomercury species in liquid samples taken in the field indicated the presence of methyl mercury. The amounts were small, but the high concentrations of solids in these samples made quantitation challenging.

Table 5. Moisture Content and LOI, Average and Standard Deviation

ID No.	Sample Type	Moisture Content	LOI
02-002	Fly ash	4.07 ± 0.03%	24.2 ± 0.1%
02-003	Fly ash	2.59 ± 0.01%	19.3 ± 0.0%
02-007	Fly ash	3.99 ± 0.12%	24.4 ± 0.9%
02-069	Fly ash	0.69 ± 0.00%	12.6 ± 0.0%
02-070	Fly ash	0.15 ± 0.02%	5.85 ± 0.01%
02-071	Fly ash	1.18 ± 0.01%	17.2 ± 0.0%
02-072	Fly ash	0.13 ± 0.03%	5.18 ± 0.02%
02-074	Fly ash	0.22 ± 0.01%	6.19 ± 0.01%
02-076	Fly ash	0.44 ± 0.02%	21.0 ± 0.1%
03-004	Fly ash	0.12 ± 0.01%	3.48 ± 0.01%
03-005	Fly ash	0.17 ± 0.00%	3.59 ± 0.02%
03-007	Fly ash	0.15 ± 0.01%	4.54 ± 0.01%
03-017	Fly ash	0.06 ± 0.01%	0.96 ± 0.00%
03-018	Fly ash	0.09 ± 0.00%	0.97 ± 0.01%
03-060	Fly ash	0.15 ± 0.00%	2.28 ± 0.04%
03-061	Fly ash	0.19 ± 0.00%	1.00 ± 0.01%
03-087	Fixated scrubber sludge	31.3 ± 0.1%	3.80 ± 0.20%
04-007	Fly ash	0.08 ± 0.00%	2.56 ± 0.07%
04-031	Fly ash	0.12 ± 0.01%	0.64 ± 0.07%
04-032	Fly ash	0.11 ± 0.01%	1.09 ± 0.02%
04-033	Fly ash	0.22 ± 0.03%	1.27 ± 0.02%
04-034	Fly ash	0.16 ± 0.03%	27.3 ± 0.2%
04-035	Fly ash	0.19 ± 0.02%	2.45 ± 0.14%

Data Reduction and Interpretation

Analysis of the carbon forms data revealed that samples with anisotropic or isotropic coke as the dominant carbon form included samples with the higher mercury content.

No correlation could be made between the total and leachable mercury concentrations for the samples tested to date.

PLANS FOR NEXT QUARTER

- Send chosen sample to other participants in the DOE NETL informal interlaboratory round-robin experiment on leaching procedures.
- Additional samples from mercury control technology tests are expected.
- Continue moisture content and LOI analyses.

Table 6. Mercury and Trace Element Leachate Concentrations, µg/L

ID No.	Test	Sample Type	As	Cd	Cr	Pb	Hg	Ni	Se	pH
03-011	TCLP	Fly ash	1500	37.0	440	37.0	0.21	280	170	4.15
03-005	SGLP	Fly ash	2.9	7.4	<2.0	<2.0	0.02	66.0	16.0	5.00
03-005	SGLP	Fly ash	NA	NA	NA	NA	<0.01	NA	NA	5.00
03-005	SGLP	Fly ash	5.9	8.1	<50.0	<2.0	<0.01	60.0	13.2	4.98
03-067	SGLP	FGD slurry	49.0	0.2	5.2	<2.0	<0.10	140	770	7.04
04-029	SGLP	Fly ash	<2.0	<0.2	24.0	<2.0	0.02	<2.0	2.1	12.09
04-030	SGLP	Fly ash	27.0	1.4	400	<2.0	<0.01	<2.0	220	11.65
04-031	SGLP	Fly ash	23.0	1.5	410	<2.0	0.01	<2.0	180	11.70
04-032	SGLP	Fly ash	28.0	1.2	330	<2.0	<0.01	<2.0	220	11.00
04-033	SGLP	Fly ash	31.0	1.3	350	<2.0	<0.01	<2.0	160	11.41
04-035	SGLP	Fly ash	<2.0	<0.2	56.0	<2.0	0.08	<2.0	18.0	12.60
04-036	SGLP	Fly ash	<2.0	0.3	68.0	3.0	0.02	<2.0	20.0	12.54
04-036	SGLP	Fly ash	NA	NA	NA	NA	1.0	NA	NA	12.54
04-054	SGLP	Fly ash	840	1.9	17.0	<2.0	NA	5.6	8600	NT
03-060	30 LTL	Fly ash	<2.0	<0.2	6.3	3.0	NA	4.5	8.5	12.46
03-061	30 LTL	Fly ash	<2.0	<0.2	3.0	3.6	NA	4.1	9.8	12.63
03-062	30 LTL	Fly ash	<2.0	<0.2	3.6	<2.0	<0.01	<2.0	<2.0	12.34
03-063	30 LTL	Fly ash	38.0	0.6	39.0	<2.0	<0.01	<2.0	43.0	11.49
03-075	30 LTL	Fly ash	20.0	0.4	<2.0	2.9	<0.01	<2.0	42.0	12.41
03-076	30 LTL	Fly ash	5.2	0.3	<2.0	<2.0	<0.01	<2.0	17.0	12.41
03-077	30 LTL	Fly ash	7.6	0.2	16.0	<2.0	<0.01	<2.0	71.0	11.47
03-079	30 LTL	Fly ash	45.0	4.2	270	<2.0	<0.01	<2.0	40.0	11.60
03-080	30 LTL	Fly ash	35.0	2.0	130	<2.0	0.11	<2.0	24.0	11.78
03-081	30 LTL	Fly ash	230	6.0	260	<2.0	0.01	<2.0	110	11.34
03-088	30 LTL	Fly ash	23.0	7.6	160	<2.0	<0.01	5.4	16.0	11.21
04-003	30 LTL	Fly ash	310	0.9	69.0	<2.0	0.10	<2.0	490	9.38
04-004	30 LTL	Fly ash	140	1.0	98.0	<2.0	<0.01	<2.0	190	10.57
04-006	30 LTL	Fly ash	3.4	0.4	49.0	<2.0	0.08	<2.0	110	11.37
04-007	30 LTL	Fly ash	<2.0	<0.2	7.3	2.2	NA	11.0	27.0	12.54
04-029	30 LTL	Fly ash	<2.0	<0.2	5.1	<2.0	NA	4.0	<2.0	12.36
04-030	30 LTL	Fly ash	8.1	1.9	640	<2.0	NA	5.6	53.0	11.78
04-031	30 LTL	Fly ash	10.0	2.0	650	<2.0	NA	4.4	54.0	11.82
04-033	30 LTL	Fly ash	10.0	2.0	580	<2.0	NA	5.8	65.0	11.55
04-035	30 LTL	Fly ash	<2.0	<0.2	<2.0	<2.0	NA	9.6	<2.0	12.65
04-036	30 LTL	Fly ash	<2.0	<0.2	<2.0	<2.0	NA	8.2	<2.0	12.61
03-004	60 LTL	Fly ash	118	1.1	10.1	<2.0	0.01	8.1	125	7.29
03-005	60 LTL	Fly ash	6.5	7.2	<2.0	<2.0	0.24	70.0	48.9	5.59
03-060	60 LTL	Fly ash	<2.0	<0.2	11.0	2.4	0.07	<2.0	11.0	12.38
03-060	60 LTL	Fly ash	NA	NA	NA	NA	<0.01	NA	NA	12.38
03-061	60 LTL	Fly ash	<2.0	<0.2	3.2	8.5	0.33	<2.0	14.0	12.58
03-062	60 LTL	Fly ash	5.2	<0.2	5.2	<2.0	<0.01	<2.0	3.8	12.40
03-065	60 LTL	Gypsum	<2.0	<0.2	<2.0	<2.0		10.0	2.7	7.99
03-074	60 LTL	Dust collector ash	2.4	<0.2	<2.0	<2.0	<0.10	<2.0	<2.0	11.50
03-075	60 LTL	Fly ash	26.0	0.5	<2.0	2.1	0.13	<2.0	42.0	12.44
03-076	60 LTL	Fly ash	12.0	0.3	<2.0	<2.0	0.05	<2.0	14.0	12.48
03-076	60 LTL	Fly ash	NA	NA	NA	NA	<0.01	NA	NA	12.48
03-079	60 LTL	Fly ash	49.0	4.4	280	<2.0	<0.01	<2.0	38.0	11.60
03-079	60 LTL	Fly ash	59.8	4.0	250	<2.0	<0.05	<2.0	38.9	11.56
03-079	60 LTL	Fly Ash	NA	NA	NA	NA	<0.01	NA	NA	11.60
03-080	60 LTL	Fly ash	29.0	2.1	140	<2.0	<0.01	<2.0	24.0	11.84
03-080	60 LTL	Fly ash	29.2	2.1	110	<2.0	0.04	<2.0	22.7	11.80
03-081	60 LTL	Fly ash	220	5.6	270	<2.0	0.12	<2.0	92.0	11.31
03-081	60 LTL	Fly ash	NA	NA	NA	NA	0.02	NA	NA	11.31
03-081	60 LTL	Fly ash	226	5.4	230	<2.0	0.02	<2.0	98.2	11.25
03-082	60 LTL	FGD filtercake	<2.0	0.5	<2.0	<2.0	<0.01	25.0	45.0	7.57
03-084	60 LTL	Fixated scrubber sludge	<2.0	0.5	2.4	<2.0	<0.01	3.5	2.0	11.94

Continued . . .

Table 6. (continued)

ID No.	Test	Sample Type	As	Cd	Cr	Pb	Hg	Ni	Se	pH
03-084	60 LTL	Fixated scrubber sludge	<2.0	0.5	2.5	<2.0	<0.01	3.7	<2.0	11.94
03-087	60 LTL	Fixated scrubber sludge	19.0	0.4	3.3	<2.0	<0.01	2.1	<2.0	11.50
03-088	60 LTL	Fly ash	23.0	8.3	180	<2.0	<0.01	5.6	19.0	11.03
03-089	60 LTL	FGD	<2.0	<0.2	<2.0	<2.0	<0.01	13.0	8.2	7.85
04-003	60 LTL	Fly ash	280	0.7	71.0	<2.0	<0.01	<2.0	490	9.08
04-003	60 LTL	Fly ash	336	0.8	70.0	<2.0	0.01	<2.0	514	9.13
04-004	60 LTL	Fly ash	140	0.8	100	<2.0	0.08	<2.0	180	10.69
04-006	60 LTL	Fly ash	7.3	0.3	53.0	<2.0	0.09	<2.0	76.0	11.31
04-007	60 LTL	Fly ash	<2.0	<0.2	6.7	<2.0	NA	10.0	17.0	12.52
04-029	60 LTL	Fly ash	<2.0	<0.2	2.3	<2.0	NA	4.8	<2.0	12.45
04-030	60 LTL	Fly ash	11.0	2.4	670	<2.0	NA	3.3	63.0	11.64
04-031	60 LTL	Fly ash	12.0	2.3	680	<2.0	NA	2.9	60.0	11.71
04-033	60 LTL	Fly ash	10.0	2.5	620	<2.0	NA	4.7	71.0	11.43
04-035	60 LTL	Fly ash	<2.0	<0.2	2.1	<2.0	NA	6.2	<2.0	12.54
04-036	60 LTL	Fly ash	<2.0	<0.2	2.1	<2.0	NA	5.4	<2.0	12.59
Blank		Blank	<2.0	<0.2	<2.0	<2.0	NA	2.2	<2.0	5.40
Container Blank		Blank	<2.0	<0.2	<2.0	<2.0		<2.0	<2.0	6.94

NT=Not Tested

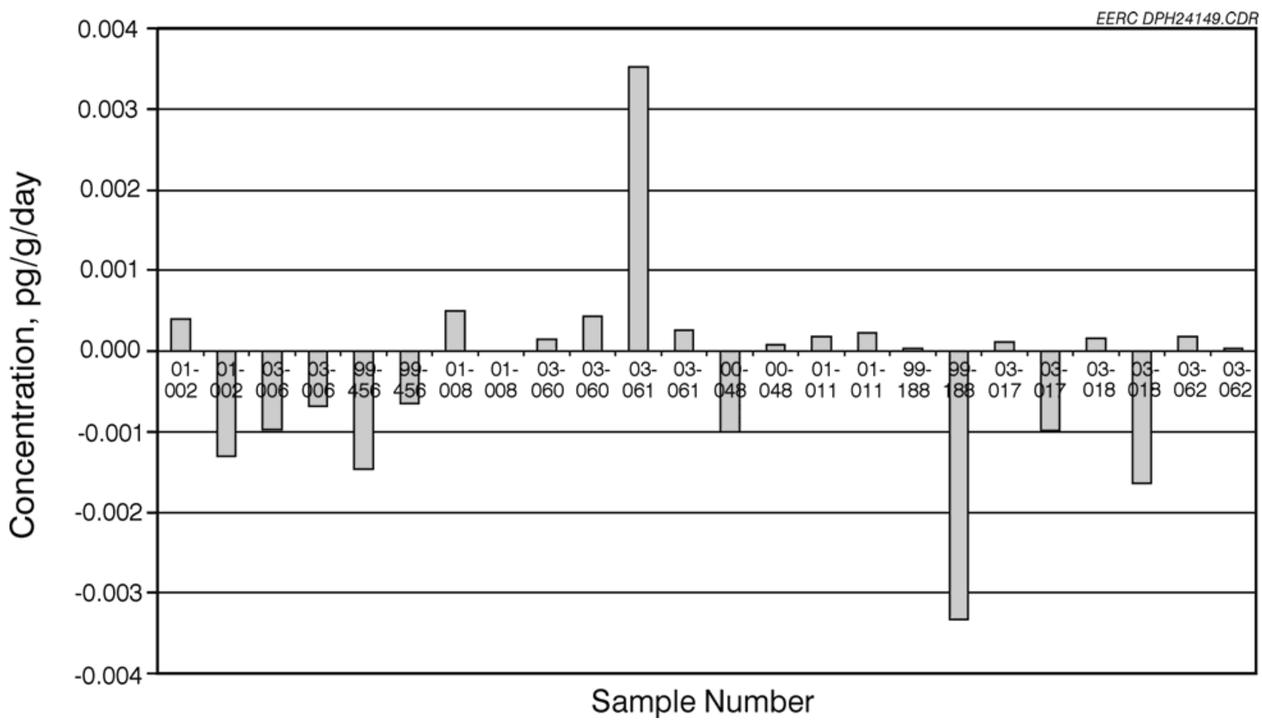

Figure 1. Average long-term ambient-temperature mercury release or sorption as related to blank values, pg/g/day. Positive values indicate release, and negative values indicate sorption of mercury.

Table 7. Initial versus Final Total Mercury Concentration for Selected Samples, pg/g

ID No.	Sample Type	Initial Concentration	Final Concentration
01-002	Fly ash	0.18 ± 0.01	0.20 ± 0.00
01-008	Fly ash	1.22 ± 0.08	1.26 ± 0.02
03-018	Fly ash	0.29 ± 0.00	0.30 ± 0.00
03-061	Fly ash	0.58 ± 0.06	0.61 ± 0.01
99-188	Fly ash + dry FGD	0.11 ± 0.01	0.12 ± 0.01

- Finish LTL on samples started this quarter. Continue leaching on any new samples from mercury control technology tests.

- Determine total mercury content of remaining long-term ambient-temperature mercury vapor release experiment samples from the first sample set. Initiate second sample set.

- Continue mercury thermal desorption curves.

- Initiate microbiologically mediated mercury release experiment.

- Continue analyses and interpretation of field data. Results from University of Nevada is expected.

- Initiate preparation of Year 3 continuation application.

LIST OF ACRONYMS

AF	atomic fluorescence
CCB	coal combustion by-product
DOE	U.S. Department of Energy
EERC	Energy & Environmental Research Center
FGD	flue gas desulfurization
GC	gas chromatograph
LOI	loss on ignition
LTL	long-term leaching
NETL	National Energy Technology Laboratory
SGLP	Synthetic groundwater leaching procedure
SPME	Solid-phase microextraction
TCLP	toxicity characteristic leaching procedure